

Evaluating A Hands-On Training Program For Improving Laboratory Technicians' Skills In Molecular Diagnostic Techniques

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Abstract:

Molecular diagnostic techniques like polymerase chain reaction (PCR) are becoming essential for clinical laboratories. However, many technicians have insufficient hands-on training and experience performing these techniques. This study evaluated a two-day intensive PCR training program for laboratory technicians in Riyadh, Saudi Arabia. A mixed methods approach collected pre/post-training surveys, knowledge tests, self-efficacy ratings, and qualitative interviews. Participants included 24 laboratory technicians from six hospitals undergoing the training. Knowledge improved significantly from mean of 53.8% to 88.9% ($p < 0.001$). Self-efficacy increased from mean of 3.2 to 4.6 out of 5 ($p < 0.001$). Participants described enhanced technical and troubleshooting abilities, though desired further hands-on time. Survey analysis and interviews suggest key program strengths were expert trainers, practical demonstrations, and small group work. Weaknesses included short duration and need for individual technique practice. Overall, this targeted hands-on PCR training program significantly improved technicians' knowledge, skills, and confidence. Study outcomes can guide enhancements to laboratory molecular training programs in Saudi Arabia and

globally, helping expand staff capabilities as molecular diagnostics diffuse into routine care.

Keywords: Molecular diagnostics, PCR, laboratory technician, training program, hands-on learning, Saudi Arabia.

Introduction:

Molecular biology techniques such as polymerase chain reaction (PCR) have become essential tools in clinical diagnostics and medical laboratory services worldwide (Albarrak et al., 2015; Azhar et al., 2021). PCR can rapidly detect infectious pathogens, genetic mutations, and other genomic factors guiding diagnosis and treatment decisions (Alasmari et al., 2021). Particularly amid the COVID-19 pandemic, availability of PCR testing has been crucial globally and in Saudi Arabia. However, transitioning PCR and other molecular methods into mainstream clinical practice has been inconsistent, as many technicians lack sufficient training and practical skills (Aldakhil et al., 2021; Ibrahim & Albarrak, 2021). Laboratory technicians form the backbone of effective PCR implementation (Abu-Zaid & Alyahya, 2021). Developing their hands-on capabilities in these emerging diagnostic techniques is critical.

International guidelines and Saudi Lab Manual standards emphasize comprehensive practical training as key for laboratory staff proficiency in molecular testing (Younis, 2020; SLMB, 2022). But many conventional programs rely heavily on lectures and written materials without opportunities for hands-on practice (Khandait et al., 2011). Training workshops with expert demonstrations, instrument operation, troubleshooting, and team problem-solving can fill this need. These are especially important for practicing technicians whose prior education lacked molecular biology exposure (Badrack, 2013). A growing literature supports intensive short hands-on molecular training courses, but few studies have evaluated programs for the Saudi context.

This mixed methods study aimed to assess outcomes from a two-day intensive hands-on PCR training workshop for 24 laboratory technicians in Riyadh, Saudi Arabia. Specific objectives included:

1. Evaluating technicians' PCR knowledge and self-efficacy before and after training
2. Exploring perspectives and experiences regarding the workshop's strengths and areas for improvement through qualitative interviews

3. Generating recommendations to enhance hands-on molecular biology training programs for Saudi laboratory staff

The findings provide valuable insights to help expand Saudi technicians' capabilities in diagnostic PCR and other emerging molecular techniques, enabling broader implementation.

Literature Review

Molecular Diagnostics Training Needs
Molecular diagnostics has rapidly advanced in clinical laboratories worldwide, with polymerase chain reaction enabling rapid, sensitive, and cost-effective analysis of viruses, bacteria, mutations, and other genomic factors from clinical samples (Alagaili et al., 2014). However, successfully integrating PCR and other molecular techniques into routine practice requires extensive staff training. Surveys of lab managers in the Middle East highlight lack of qualified staff as a major barrier, along with limited equipment access and standardization issues (Matta et al., 2021). Diagnosing COVID-19 has further increased demands for molecular testing. But education systems have not kept pace, with both new technicians and established staff lacking robust molecular training (Ibrahim & Albarrak, 2021; Witt et al., 2021). Saudi Arabia similarly faces molecular skills gaps among laboratory professionals. A survey of 303 lab technicians in Riyadh found just 36% competent in PCR skills, with 44% having no PCR experience (Aldakhil et al., 2021). Qualitative data highlighted inadequate hands-on training. Changing guidelines and limited quality assurance also presented challenges. Closing knowledge and training gaps will be critical as Saudi Arabia continues expanding clinical molecular diagnostics (Alessa et al., 2022).

Hands-on Training Approaches

Best practice guidelines globally emphasize hands-on experience as the cornerstone of applied molecular diagnostics training (CSMLS, 2014; WHO, 2008). Competency requires progressing through demonstration, supervision, and eventually independent practice (Younis, 2020). Short workshops, simulation exercises, and on-the-job training allow building proficiency in techniques like PCR setup, thermocycling, results analysis, and troubleshooting (Azhar et al., 2021). Hands-on practice also develops soft skills in areas like quality assurance, communications, and ethics (Khandait et al., 2011). However,

traditional curricula often have an overly theoretical focus without sufficient practical learning opportunities (Badrick, 2013).

Targeted intensive hands-on courses offer a useful solution to provide practical molecular skills development in focused areas like PCR. For instance, a five day workshop for lab staff in Pakistan significantly improved PCR knowledge and ability to troubleshoot issues (Khan et al., 2012). A US program using expert demonstrations, instrument operation, and biological sample testing increased learner confidence and ability to implement molecular techniques (Chen et al., 2011). Blended approaches with online and in-person components show additional promise (Witt et al., 2021).

Saudi laboratory standards likewise highlight hands-on training paired with theory and e-learning for optimal molecular diagnostics education (SLMB, 2022). Developing more intensive practical programs tailored to different staff levels and techniques can help close knowledge gaps as advanced molecular testing diffuses into Saudi clinical practice (Lebedev et al., 2021). But few studies have evaluated intensive hands-on molecular training programs for Saudi lab technicians specifically. This research helps address that evidence gap.

Theoretical Framework

Kirkpatrick's four level evaluation model provides a theoretical framework for assessing training program effectiveness (Kirkpatrick & Kirkpatrick, 2006). Level 1 measures learners' reactions, including perceptions of relevance and engagement. Level 2 evaluates learning through pre/post testing. Level 3 examines on-the-job behavior change. Level 4 assesses organizational results like productivity and quality. This study focuses on Levels 1 and 2, gathering participant reactions qualitatively and evaluating knowledge gains through pre/post testing. The model helps systematically appraise key proximal outcomes of hands-on molecular training for building technicians' capabilities.

Methods

Study Design and Setting

This convergent parallel mixed methods study evaluated a two-day hands-on PCR training program in May 2022 for laboratory technicians at six hospitals in Riyadh, Saudi Arabia.

Participants

A purposive sample of 24 laboratory technicians with limited prior PCR experience were recruited for the MOH-sponsored workshop. Sixteen (67%) were men and eight (33%) women. They had 2-10 years of lab experience and came from the six participating hospitals.

Intervention

The PCR training workshop spanned 16 hours over two full days. It consisted of lectures, expert demonstrations, hands-on practice, simulated cases, small group activities, and troubleshooting. Topics included PCR principles, techniques, instruments, quality assurance, and applications.

Quantitative Methods and Analysis

On day one, participants completed a pre-training survey and 30-point knowledge test on PCR concepts. The test and survey were repeated post-training. Pre-post scores were compared using paired t-tests. The survey also rated self-efficacy on a five-point Likert scale from strongly disagree (1) to strongly agree (5). Differences were analyzed using Wilcoxon signed rank tests.

Qualitative Methods and Analysis

Twelve semi-structured interviews explored perspectives on the training's strengths, weaknesses, and desired improvements. Transcripts were coded through iterative categorization and thematic analysis using NVivo 12 software. Quantitative and qualitative data were integrated during analysis.

Ethical Considerations

Informed consent was obtained. Identifiers were removed during transcription, with pseudonyms used. The institutional review board approved the protocol.

Results

Quantitative Findings

Mean scores on the PCR knowledge test improved significantly from 16.1/30 points (53.8%) at baseline to 26.7/30 points (88.9%) post-training ($p < 0.001$). The proportion of technicians scoring over 70% on the test increased from 4% on day one to 87% on day two. Table 1 displays the test score results.

Table 1: Pre-Post Knowledge Test Results among Participants (n=24)

Time Point Mean Score (SD) Minimum Maximum

Pre-Training (Day 1) 16.1 (4.2) 10 23

Post-Training (Day 2) 26.7 (2.1) 22 30

p value <0.001

Self-efficacy for performing PCR improved from a mean of 3.2 pre-workshop to 4.6 post-workshop ($p<0.001$) on the 5-point scale. For operating thermocyclers, self-efficacy increased from 2.8 to 4.5 ($p<0.001$). Troubleshooting self-efficacy rose from 2.5 to 4.3 ($p<0.001$).

Qualitative Findings

Four major themes regarding the PCR training workshop emerged: Strengths

- Hands-on practice sessions: “Actually extracting DNA and doing gel electrophoresis myself really helped cement the concepts.” – Sarah, technician
- Expert demonstrations: “Watching the trainers walk us through PCR protocols and instruments was extremely valuable.” – Khalid, technician
- Small group problem-solving: “Discussing real scenarios in small teams made me think critically.” – Ali, technician

Weaknesses

- Limited individual hands-on time: “With the large group size, we couldn’t all individually practice the full workflow.” – Leena, technician
- Need for more troubleshooting: “I would have liked to deliberately induce and problem-shoot more PCR errors.” – Faisal, technician
- Short duration: “Trying to cover so much in two days felt rushed for a beginner.” – Samira, technician

Desired Improvements

- More hands-on time in the lab: “Double the hands-on practice time to cement skills.” – Reem, technician
- Smaller groups: “Breaking into groups of 4-5 would allow everyone to have more hands-on experience.” – Khaled, technician
- Longer duration: “Stretching to 2.5 or 3 days would allow less cramming of material.” – Ali, technician

Recommended Changes

- Individual practice time: “Everyone should extract DNA and run a full PCR themselves, even if it takes longer.” – Leena, technician
- Simulated troubleshooting: “Build in specific scenarios to troubleshoot gels, cycling, contamination.” – Sarah, technician
- Refresher sessions: “Follow-up sessions to reinforce skills would be hugely helpful.” – Samira, technician

In summary, participants valued the hands-on components, expert trainers, and interactive elements, which built knowledge, skills, and confidence. However, limited individual practice time and duration were weaknesses. Implementing more tailored hands-on content, smaller groups, longer workshops, and refresher courses could optimize benefits.

Integration of Quantitative and Qualitative Results
The qualitative themes reinforced and expanded on the quantitative survey findings. The significant knowledge and self-efficacy gains on tests and ratings aligned with descriptions of becoming more proficient through hands-on practice and observations. However, interviews provided nuanced input on desired improvements despite overall gains, including more individual practice time, troubleshooting, and duration. Integrating methods thus provides a multidimensional assessment of the training program's strengths and areas for optimization.

Discussion

This PCR training program evaluation revealed significant improvements in technicians' knowledge, skills, and confidence through a well-received hands-on workshop. Mean scores on the PCR knowledge test increased from 53.8% to 88.9%, with far more technicians achieving >70% competency. Given molecular techniques' increasing prominence in Saudi clinical laboratories, developing this applied knowledge is crucial (Aldakhil et al., 2021). Self-efficacy for PCR procedures and troubleshooting also improved markedly. Enhanced confidence will facilitate practice adoption (Lebedev et al., 2021).

Participant interviews provided further insights. Hands-on practice, expert demonstrations, small group work, and discussions were viewed extremely positively in building skills. This aligns with literature on active learning for applied molecular competencies (Khan et al., 2012; Witt et al., 2021). Technicians also

suggested improvements like more individual hands-on time and emphasis on troubleshooting scenarios. Optimizing these facets could strengthen outcomes.

Overall, the intensive workshop filled an important training gap for busy practicing technicians who lacked prior PCR exposure. Developing this cohort's molecular capabilities will support Saudi laboratories' capacity to implement PCR testing. Study outcomes including the high satisfaction could encourage similar programs. Limitations included the small sample and lack of long-term competency assessment. Follow-up studies should evaluate graduates' applied skills.

Conclusion

This hands-on PCR training program significantly expanded technicians' knowledge, skills, and confidence. While enhancements were suggested, outcomes demonstrate intensive practical workshops' value for molecular professional development. Scaling such programs alongside continued education reforms can enable Saudi laboratories to realize PCR's full clinical potential. The study provides an evaluative framework to guide implementation and optimization of hands-on molecular training initiatives locally and globally.

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